Article by Alexander Graham Bell, April 10, 1891

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1910, March 22, Beinn Bhreagh Recorder EDITORIAL AND ARTICLES ON THE POSSIBILITY OF SEEING BY ELECTRICITY By Alexander Graham Bell

(The following article was dictated by Dr. Bell April 10, 11, 12 and 13, 1891 and taken down by Mr. Arthur W. McCurdy. These have been preserved in a collection of dictations headed “Half-hour Evening Talks on Various Subjects”. MBMcC)

April 10, 1891 :— It is obvious that a cannon ball can only move in one direction and with one velocity at any given moment of time. Can we not generalize and say that this is true of the smallest masses of matter imperceivable to the senses, as well as of those grosser bodies whose movements appeal to the eye?

This thought lay at the root of the telephone, and phonograph, and graphophone. The needle point of the phonograph recorder, or receiver, is only capable of a single motion or vibration; and yet this point may cut a single vibration on the record blank that may produce in the ear the sensation of a multitude of separate and distinct sounds.

Now the thought that has been in my mind for years is this:— That what is true of the cannon ball, and the particles of the medium that conduct sound, and the vibrating point of the phonograph style, must also be true of the particles of the medium whose vibrations, or motions, occasion in the eye the sensation of sight.

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When we analyze white light by means of a prism, we obtain a colored spectrum indicating the simultaneous presence, in the matter of the luminiferous medium, of multitudinous vibrations, or tremors, differing from one another in frequency and amplitude: But surely it is inconceivable that any single particle of the luminiferous medium can move except in one path, or can execute more than one kind of vibration at the same time.

What is true of one particle of the medium, must be true of all. The resolution, therefore, of that form of vibration that we call white light into various colors, or pitches of light, is an effect of analysis due to the prism, comparable to the analysis, by the ear, of a single graphophonic vibration into a multitude of sounds.

April 11, 1891 :— So, also, the perception of an image by the eye is an effect of analysis due to the eye itself, and non-existent in the medium outside. There is certainly nothing in the medium, or in the motions of the particles of the medium, approaching even approximately an image. The particles of the luminiferous medium are simply in a state of vibration, or tremor, analogous to the vibrations of the particles of air when sound is heard.

Is not the clear perception of every instrument in the marine band, as heard from the phonograph, a perception of a sound image by the ear, analogous to the perception of a light image by the eye? If so, should it not be within the bounds of possibility to produce an instrument that should do for the eye, what the graphophone and telephone 3 do for the ear. Should it not be possible to see by telegraph; and obtain, upon a moving cylinder, a record of things seen, from which record the moving scenes should be reproduced at will to the eye?

The point with which I am particularly struck, is the undoubted fact, that no image exists in the medium outside of the eye: That there is nothing there, but vibration— analogous to the vibrations of sounds in this respect, that each particle of the medium moves in a single path, and in a single way — a resultant of all the vibratory movements traversing the medium.

Wave-like effects, rebounding from the walls and objects in the room, cross and recross one another, as waves of sound in the air, or ripples on the surface of the sea: But each particle of the medium moves singly and alone in a resultant path.

If we could cause a single particle of the luminiferous medium in a distant place, to copy exactly the motion of a particle of the medium in this room, then it should be possible for an apparatus, or for an eye, to analyze the disturbances of the medium produced by this moving particle, into an image; just as the eye in this room perceives, from the disturbances of the medium here, an image of the things outside.

You can see the capitol of the United States through a pin hole:— Not only the capitol itself, but a large portion of the city of Washington.

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Picture to yourself the vibrations that are going on. An impulse of the agitated medium strikes the image of Liberty on the top of the Capitol; and, rebounding, is transferred by successive impacts from particle to particle, through the pin hole, to your eye. Similar impulses come from all parts of the landscape visible through the pin hole, to your eye. All these rectilinear impulses cross one another in that pin hole: But no particle of the medium in that pin hole can move in any other than a single way. The vibration or motion existing there, is, therefore, a resultant of all the impulses that reach it from outside.

If, then, it could be possible to cause a particle of the luminiferous medium in a pin hole in a distant place, to copy the resultant motion, why should not an eye at the distant pin hole perceive an image similar to that observed in the first case? Such a result would, I am sure, follow as a matter of course.

The difficulty lies in the copying of the resultant motion desired; but, if Hertz is right, and electricity is a motion of the same medium that transmits light and heat, it should be possible for ingenuity to devise apparatus for doing this by electrical means. It should be possible to see by telegraph.

April 12, 1891 :— There must be countless myriads of particles in a pin hole; but the pin hole corresponds, for the eye, to the needle point of the graphophone for the ear. There are doubtless myriads of air particles 5 in the space occupied by the point of the recording or reproducing style; and the style copies approximately, not the motion of a single particle, but the mean motion of all the particles in that space. This is sufficient, so far as the ear is concerned, for the reproduction of complicated effects.

So with the pin hole. As a matter of fact the rectilinear impulses propagated from objects through a pin hole do form upon a sheet of paper, held near, an image of the objects themselves sufficiently distinct to be perceived as a picture by the eye. Hence, while it may be impossible to copy in a distant place the motion of a single particle of the luminiferous medium, it will be sufficient for the purposes of sight to copy the mean motion of all the particles in a pin hole.

The electrical resistance of crystalline selenium is affected by light. A molecular disturbance is produced in the selenium by successive impacts of particles of the luminiferous medium, in the shape of rays of light or heat, sufficient to cause electrical disturbances in a circuit. Surely these electrical disturbances are copies of the molecular disturbances produced by the impact of light; and these molecular disturbances are copies of the disturbances in the luminiferous medium that constitute the light.

Hence, the electrical disturbances are copies of the light disturbances: That is, the variations of force or intensity or quantity, or whatever it may be called, 6 in the electrical circuit, correspond in character to those disturbances of the luminiferous medium that constitute the light; just as the electrical disturbances in a telephone circuit correspond in character to the aerial disturbances that cause the sensation of sound. We have some electrical effect in the selenium circuit corresponding to what is called an “Undulatory” current of electricity in telephony.

Now place two pieces of crystalline selenium in the same circuit with an electro-motive force. Keep one piece in the dark, and expose the other to light.

The electrical disturbances produced by the impact of the ray of light pass through the second piece of selenium in the dark. Surely these electrical disturbances will produce, in the darkened selenium, molecular disturbances similar in character; and these molecular disturbances should produce disturbances in the luminiferous medium in contact with the darkened selenium.

Now I see no reason to doubt that the character of the variations in the chain of media will remain unchanged; hence the darkened selenium should emit light , of similar color and character to that which originally caused the disturbance

For example: Let the original disturbance be a vibration of some sort capable of expression by a graphical curve. Then the final disturbance should contain a vibration capable of expression by the same curve.

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The effect might be much feebler; but the frequencies of the vibrations would be the same, and the relative amplitudes of the successive vibrations should be copied, though not the absolute amplitude. Hence, the light produced, would be the same in character and kind as that which fell on the illuminated selenium, though much feebler in intensity. I am convinced that the effect would be there; though it may be doubtful whether the human eye could perceive it.

A similar doubt long prevented the practical realization of the telephone, after the complete conception had been reached; but it was found upon experiment to be groundless.

The eye is a much more delicate organ than the ear; and the suggestion is worthy of experiment.

On account of the enormous resistance of selenium, a voltaic battery might be insufficient as a source of electro-motive force, quite apart from the fact that disturbances are probably existent in a voltaic circuit corresponding in character to the chemical disturbances, or molecular vibrations, going on in the battery.

The experiment would probably be more hopeful with a charged condenser, or jar, as the source of electro-motive force:— Statical, instead of dynamical electricity.

But we must not forget that Professor Adams, of London, England, has shown that an electro-motive force is produced in selenium directly by the action of light; 8 so that the experiment might be tried without either a voltaic battery or a charge condenser — a simple circuit might be sufficient.

April 13, 1891 :— Should it be found upon experiment that the darkened piece of selenium emits light when the other piece is illuminated, then an apparatus might be constructed in which each piece of selenium is a mere speck, like the head of a small pin, the smaller the better.

The darkened selenium should be placed in a cuplike receiver which can fit over the eye, a sheet of glass or other transparent material being placed between the selenium and the eye in case of accident.

Then, when the first selenium speck is presented to an illuminated object, it may be possible that the eye in the darkened receiver, should perceive, not merely light, but an image of the object, as though we were looking at it through a pin hole in a card.

Selenium, however, is a difficult substance to work with; and perhaps tellurium, or lamp-black, would prove more suitable. Tellurium, like selenium, is sensitive to light, though in a much less degree; and it has the advantage of being a good conductor of electricity.

Those substances that produce the loudest sounds in radiophonic experiments, under intermittent illumination, are surely those whose molecules are most easily moved by the luminiferous medium.

If this is so, lamp-black should be of all substances the best. Lamp-black also, is a conductor of electricity; 9 and experiments in the past have demonstrated the fact that it can be used in place of selenium in an electrical radiophone.